



Attorney Docket: 3036/49488  
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: MARK ALAN WEST ET AL.

Serial No.: 09/737,308

Filed: DECEMBER 18, 2000

Title: IMPROVEMENTS IN OR RELATING TO INTERNET ACCESS

**CLAIM FOR PRIORITY UNDER 35 U.S.C. §119**

**Box Missing Parts**

Assistant Commissioner for Patents  
Washington, D.C. 20231

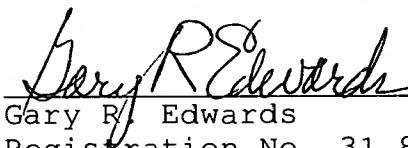
Sir:

The benefit of the filing dates of prior foreign application No. 9929882.0, filed in Great Britain on December 18, 1999 and prior foreign application No. 0024465.7, filed in Great Britain on October 6, 2000, is hereby requested and the right of priority under 35 U.S.C. §119 is hereby claimed.

In support of this claim, filed herewith are certified copies of the original foreign applications.

Respectfully submitted,

April 20, 2001

  
\_\_\_\_\_  
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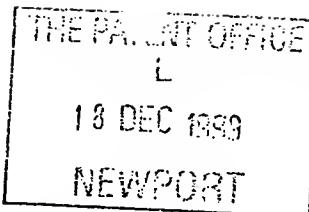
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Dated 2 January 2001

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The Patent Office

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## 1. Your reference

1999P04895/GB/R76/RMK/am

2. Patent application  
(The Patent Office ref.)

9929882.0

18 DEC 1999

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

ROKE MANOR RESEARCH LIMITED  
ROKE MANOR  
OLD SALISBURY LANE  
ROMSEY, HAMPSHIRE  
SO51 0ZN

Patents ADP number (if you know it)

5615455602

UNITED KINGDOM

## 4. Title of the invention

TCP/IP ENHANCEMENT FOR LONG LATENCY LINKS

## 5. Name of your agent (if you have one)

ROSS M. KAY

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

SIEMENS SHARED SERVICES LIMITED  
INTELLECTUAL PROPERTY DEPARTMENT  
SIEMENS HOUSE  
OLDBURY  
BRACKNELL  
BERKSHIRE  
RG12 8FZ

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Country      Priority application number  
(if you know it)      Date of filing  
(day / month / year)

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Number of earlier application      Date of filing  
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
- c) any named applicant is a corporate body.

See note (d))

# Patents Form 1/77

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Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination and search (*Patents Form 9/77*)

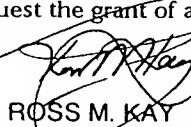
Request for substantive examination  
(*Patents Form 10/77*)

Any other documents  
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature



ROSS M. KAY

Date 16/12/1999

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12. Name and daytime telephone number of person to contact in the United Kingdom

ROSS M. KAY - 01344 396808

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## TCP/IP traffic over long latency links

Where TCP/IP traffic flows between the Internet as a whole and an essentially private, stub network across long-latency links, access to the Internet is sub-optimal. Specifically, if a mobile network built around point-to-point, high latency wireless links (for example UMTS) is connected to the Internet, the latencies involved severely restrict the performance of TCP/IP connections. TCP/IP is required to use flow control mechanisms for congestion avoidance and congestion recovery. These cause poor performance when applied to long-latency connections, but are essential to prevent the Internet from collapsing.

### Asymmetrical enhancement

Since the mobile network uses point-to-point links between a base station and a mobile terminal, the link between the base-station and the mobile terminal does not suffer from congestion. A solution to improvement performance is to place an 'enhancer' at the base station. This then acts as a gateway between the Internet at large, and the network of mobiles. Figure 1 shows a typical scenario for the enhancer.

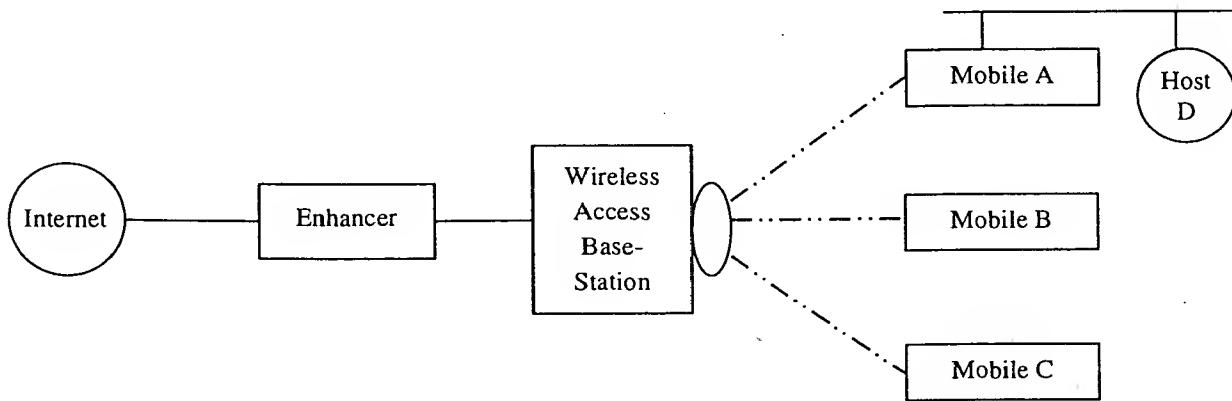


Figure 1 Asymmetrical Enhancer

The enhancer terminates any TCP connection that it receives, either from the network of mobiles (A-C) or an Internet host, by responding to the originating host as if it were the ultimate end-system. It then regenerates the connection to the end-system. By splitting the connection at this gateway, congestion control can be applied to the Internet side, not violating any of the Internet rules, but need not be applied to the network of mobiles, where it is unnecessary.

By doing this, the enhancer can apply flow-control in both directions through use of the TCP sliding window, and allow connections immediate use of the full link bandwidth into the network of mobiles.

This enhancement is asymmetric, because only data transferring from the Internet to the network of mobiles will be so affected. Any traffic flowing into the Internet will be two separate, congestion-controlled connections. Traffic flow to the mobile terminals is seen to be the most obvious direction to enhance, since accesses from the network mobiles is likely to take the form of requests for information from the Internet, in which case the responses are expected to be significantly larger than the requests.

### Connection splitting

Connection splitting is the key mechanism for enhancing TCP performance. Rather than allowing

segmented. The enhancer terminates a TCP connection on one interface (From the Internet) and re-generates it on another (To Mobile B)

By doing this, flow control and congestion management is no longer performed end-to-end, as would happen with ordinary TCP. This is important, as the wireless link has very different characteristics from the other, terrestrial, hops that packets will use. For TCP, the increase in round-trip time caused by the wireless link will adversely affect the slow-start period. This is the initial period of a TCP connection where the transfer rate is ramped up exponentially.

Figures 2 and 3 compare the use of connection splitting with an unmodified, end-to-end, TCP/IP connection. Firstly we show the end-to-end case and note that node 1 must wait for acknowledgements from node 2 (Figure 2), as the router 'R' simply relays the packets.

In the second, enhanced, case (Figure 3) the effect of the enhancer (replacing the router) between nodes 1 and 2 can be seen. Note that the two connections now have separate sequence number spaces. Nodes 1 and 2 still believe that they are communicating with each other, but the long latency connection between is effectively hidden from the end-systems.

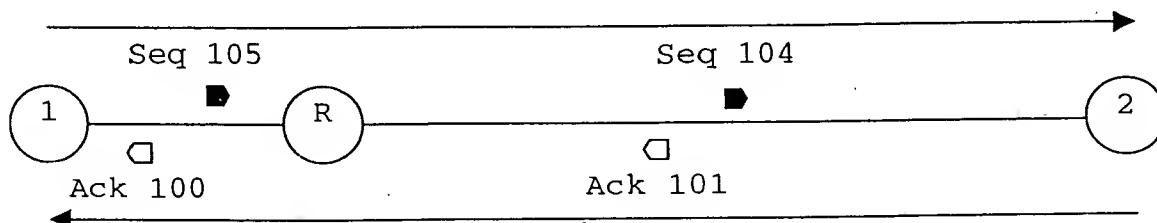


Figure 2 End-to-end TCP connection

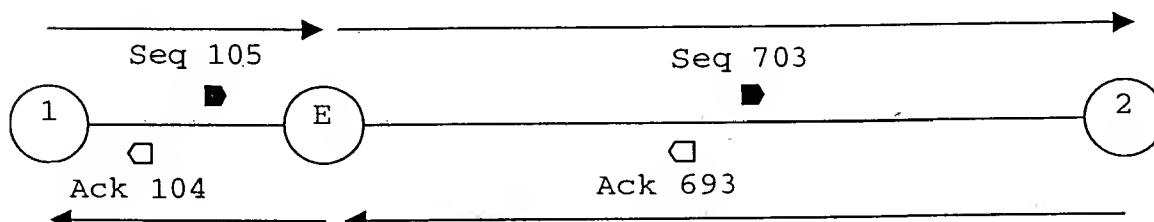


Figure 3 Split TCP connection

### Packet Isolation

The TCP connections on either side of the enhancer are isolated, so that, for example, 500 byte packets entering the enhancer from the Internet, may appear as 1kbyte packets to the mobile network. Data ordering does not change across the enhancer, so that Mobile A still perceives a single TCP/IP connection to the Internet.

### Network congestion avoidance

The congestion avoidance mechanisms within TCP are essential to prevent the so-called 'congestion collapse' of the Internet. This occurs when routers are overwhelmed with data and, rather than responding to the overload, TCP continues to aggressively transmit (and re-transmit) data.

An important point for the use of asymmetric enhancers is that once a packet has reached the interface to the wireless link, the data is transferred to the mobile station via a point-to-point link. This is important to ensure that the wireless link is not the bottleneck, so that the

network attached to the mobiles is a 'stub' network. That is, there are no networks beyond it that are routed through it.

Because of these points, it should be seen that congestion control mechanisms are not required once the wireless link has been reached. This, then, is the basis of enhancement. The connection is split at the enhancer. A TCP flow that is regenerated back into the Internet remains a standard, responsive, TCP. A TCP that is regenerated towards a mobile, however, has the congestion avoidance mechanisms removed. That is, neither slow-start (the exponential rate increase at connection start or packet drop) nor fast-recovery (halving the transmission rate on single packet loss) are implemented.

The link between the base-station and the mobile terminal may be either assured or un-assured, depending upon the wireless access technology used. The TCP retransmission mechanisms may be modified for the connection to the mobile in order to improve the response to dropped packets. This would probably consist of a more tightly bounded retransmission strategy for an unassured link with no backoff in the event of packet loss. For an assured link, the retransmission mechanism may use an extended timeout to reduce the impact of lower layer retransmissions.

Critically, regardless of the changes to the congestion mechanisms, the protocol used by the enhancer is fully interoperable with the host attached to the mobile station – all the datagrams are perfectly standard TCP/IP. The performance is enhanced because congestion avoidance is not performed over a link for which it is inappropriate.

### Symmetrical enhancement

This idea can be further extended by placing two such enhancers 'back-to-back'. This would then give symmetric enhancement. Figure 4 demonstrates that a typical environment for this sort of symmetrical enhancer would be either side of a geostationary satellite hop.

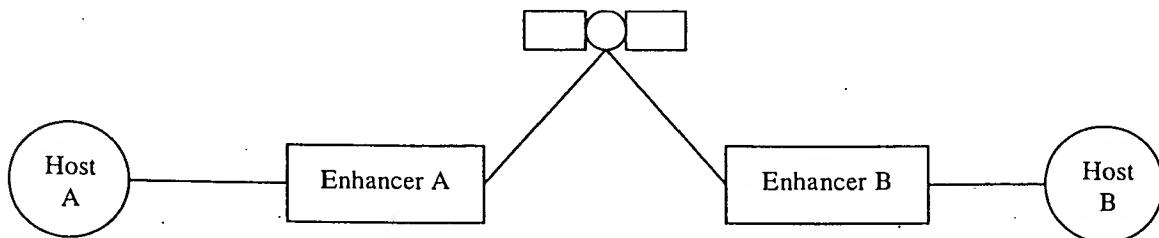


Figure 4 Symmetrical Enhancement

In this situation it is preferable to link the enhancers by a dedicated protocol, optimised for high-latency point-to-point links. The reason for this is efficiency. Given that the link is high latency, it is desirable to reduce the amount of retransmitted traffic in the event of error or loss on the link. Since this implies using a non-TCP protocol, and since the system would be deployed either side of a point-to-point link, there is no benefit in using IP, either. Therefore, an efficient point-to-point link between the enhancers offers savings in link bandwidth, by using an optimally sized header (avoiding the TCP/IP header overhead) and in link utilisation. The latter benefit comes both from reduction in unnecessary retransmissions and from reducing the volume of reverse traffic (TCP/IP generates a comparatively large volume of acknowledgements). The potential improvement is dependent upon a number of variables, including latency, link rate and error-rate.

### Multiple acknowledgement indication

The number of acknowledgements generated (and the efficacy of these) can be improved by extending the standard idea of 'piggybacking' a single acknowledgement onto an ordinary data frame in the reverse direction. Rather than just including a single value to acknowledge a single frame, a delta value is incorporated. This indicates how many contiguous frames (starting with the given acknowledgement number) have been successfully received. This can achieve large reductions in reverse traffic bandwidth and, by overlapping successive acknowledgement values, provide a more robust system with less retransmissions in the event of a single acknowledgement packet being dropped.

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